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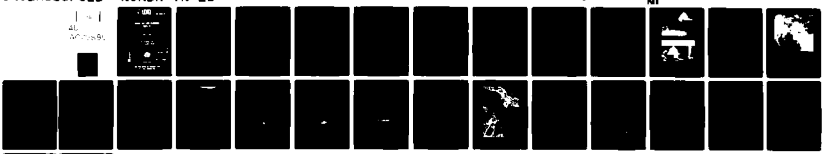

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March 1978

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NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY
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ABSTRACT

The Naval Ocean Research and Development Activity conducted an oceanographic research program (was conducted) in northern Smith Sound during middle July 1977 using USCGC WESTWIND (W-AGB 281) as the data collection platform. One aspect of the program was to investigate the water mass interactions at the narrowest portion of Smith Sound which: (1) represents the boundary between this sound and Kane Basin to the north; and (2) is the area of the most well-known semipermanent open water area--the North Water Polynya.

From an analysis of 2 West-East cross sections and a comparison of these data with data collected by the Coast Guard in 1963, it is suggested that the northern Smith Sound area is a meeting area of two different water masses: (1) a warm (>-1.0°C), dense (>26.8σ_t) mass on the eastern side of Smith Sound which enters the area from the south; and (2) a cold (<-1.0°C), low density (<26.7σ_t) mass on the western side of Smith Sound which originates in the Arctic.

It is further suggested that since the warm, dense water mass was also observed in 1963, this feature in eastern Smith Sound may be a permanent or, more likely, a semipermanent (seasonal) phenomenon and could be highly modified Atlantic Water. This latter conclusion is in contrast to the general belief that Atlantic Water does not enter Smith Sound.

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NORTHERN SMITH SOUND OCEANOGRAPHY - SUMMER 1977

I. INTRODUCTION

A. GENERAL

The Polar Oceanography Branch of the Naval Ocean Research and Development Activity (NORDA) was offered the opportunity to utilize the USCGC WESTWIND (W-AGB 281) for oceanographic research on a not-to-interfere basis during July 1977 in the Smith Sound/Kane Basin area. The decision was made to take advantage of this opportunity and conduct a multi-faceted environmental program within an extremely complex marginal ice zone, northern Smith Sound. Initial premission planning listed the following parameters as being of interest: (1) water currents; (2) subbottom structure; (3) bottom composition including cores, grabs, and photography; (4) bathymetry; (5) physical oceanographic structure; (6) volume reverberation; (7) biofouling levels; (8) magnetic anomaly variations; and (9) ambient acoustic variations at various levels. Of this list, volume reverberation, biofouling, and water currents were deferred to a later date because either necessary sensors and equipment were not available for this mission or not enough time was available to develop a viable program.

B. OBJECTIVES

With the above parameters in mind, the following objectives were listed for this mission: (1) Assess bottom and subbottom conditions to: (a) aid in determination of the most desirable locations for deployment of long-term moored oceanographic sensor packages, and (b) provide information on hardware and package design; (2) Define summer oceanographic conditions for northern Smith Sound; and (3) Determine typical variations of several types of ambient parameters: (a) high frequency acoustic, (b) lower frequency acoustic, (c) magnetic, (d) seismic, (e) pressure, and (f) temperature. To accomplish the latter objective, unmanned camps would have to be established on the ice far from the influences generated by the Coast Guard Cutter WESTWIND. The discussion presented herein addresses Objective (2) above.

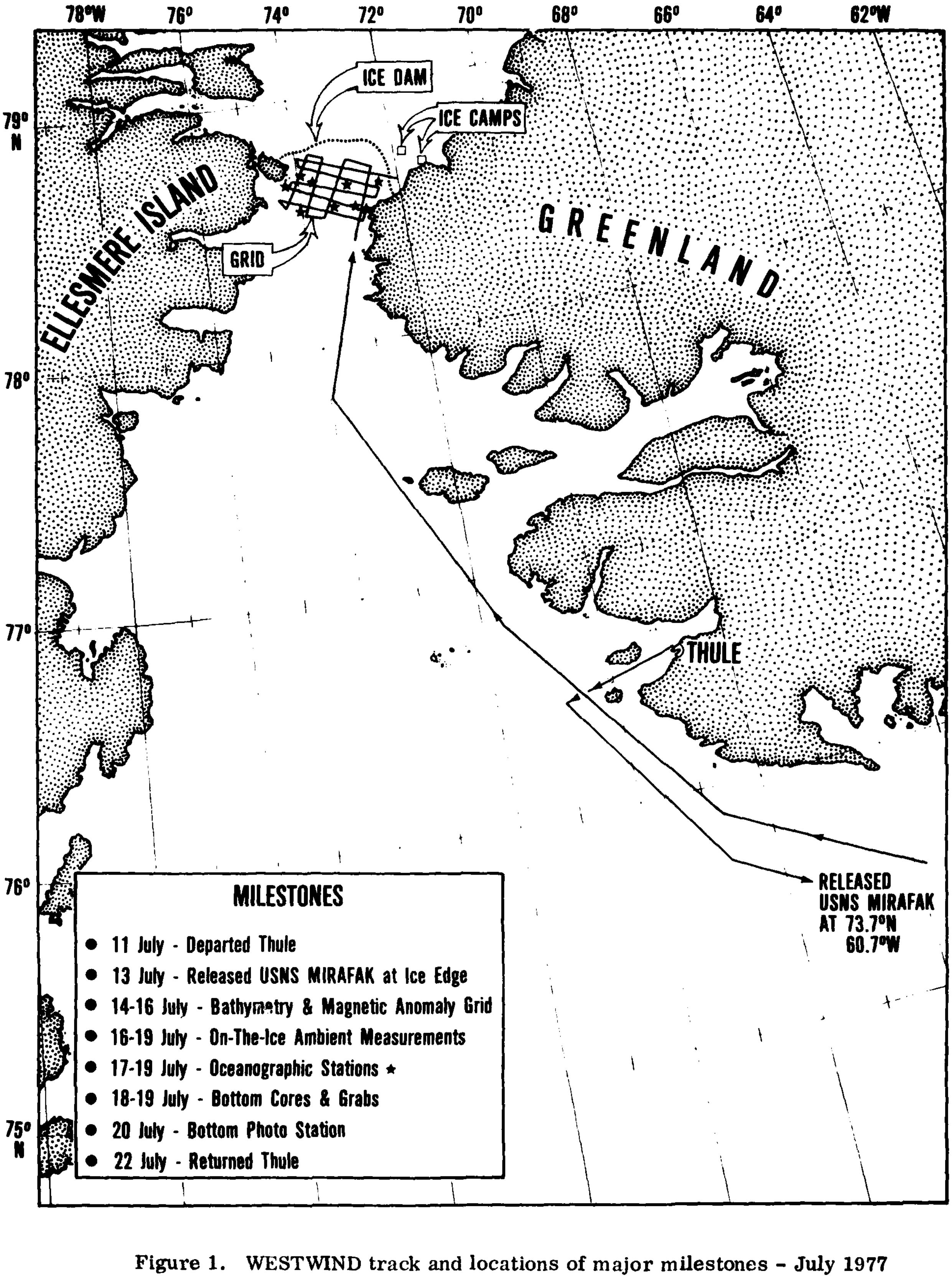

Figure 1. WESTWIND track and locations of major milestones - July 1977

C. PARTICIPATION

This program was sponsored and controlled by NORDA. However, invaluable support was provided by: (1) the Naval Oceanographic Office which supplied a scientist and needed instrumentation; (2) the Naval Surface Weapons Center which provided one physicist and the instrumentation needed for Objective (3) above; (3) the United States Coast Guard which provided the platform, reversing thermometers, other back-up instrumentation, and 3 Marine Science Technicians to assist in the shipboard oceanographic programs; and (4) the United States Coast Guard Aviation Training Center (Polar Operations) which provided helicopter support for establishing and maintaining the camps on the ice.

D. NARRATIVE

Figure 1 presents the WESTWIND track and general areas of milestones for this mission. The week of 1-7 July was set aside for equipment installation and calibration onboard WESTWIND in Thule, Greenland. Departure date was scheduled for 8 July. However, escort duties for WESTWIND delayed sailing until 11 July, and this departure was to escort another ship to the ice edge before heading to the study area in Smith Sound. The study area was reached late on 14 July nearly one week behind schedule. The magnetic anomaly and bathymetry grid was begun with no difficulty. However, the seismic reflection instrumentation failed to provide coherent data and no usable subbottom information was obtained. On 16 July the underway measurement program was completed and the ice camp sites were selected via both helicopter reconnaisance and water depth determinations using an ice drill and a portable fathometer. The high frequency camp was established on a multi-year ice floe over 200 meters of water and was made operational late on 16 July. The second camp for measuring the remaining parameters was established early on 17 July on fast ice over 50 meters of water. Several resupply flights were made to the camps to replace batteries, generator gasoline, and magnetic tapes and strip chart paper. The oceanographic station program was begun on 17 July and completed on 19 July. Also, on 19 July during a resupply flight to the camps it was observed that the ice in the ice camp areas was rapidly breaking up. The camps were dismantled and retrieved late that day. The bottom sampling program (cores and grabs) was begun on 18 July and completed on 19 July. One bottom photography station was taken on 20 July. WESTWIND returned to Thule on 22 July.

E. DATA COLLECTION METHODS

A Varian proton precession magnetometer was towed just below the surface approximately 215 meters aft of WESTWIND. This system measures the total magnetic field with a 1 gamma sensitivity. A sample was taken every six seconds and was recorded in analog form on both magnetic tape and strip chart.

WESTWIND's fathometer and transducer were used to gather the bathymetric data and worked extremely well. WESTWIND's NAVSAT computer, however, was not functioning properly. Position data were obtained by radar range and bearings to prominent features on Ellesmere Island and Greenland and were plotted on the most recent Canadian charts available.

A modified Ewing corer was utilized to collect 16 bottom cores. The corer barrel was 3.2 meters in length and was driven into the bottom by approximately 1100 kg of lead weights. One bottom grab was collected with a shipek sampler, and 16 grabs were collected with an orange peel sampler.

A Benthos camera system was used to collect photographs at the camera station. This system was comprised of a single camera, strobe, 6-volt silver-zinc batteries, and a pinger. The pinger was used in conjunction with the ship's fathometer system and an oscilloscope, to monitor the camera's distance from the bottom. A 30-meter roll of 35 mm tri-x film was exposed at this station which covered a drift track of about 1 kilometer.

A Bissett-Berman Model 9040 Salinity-Temperature-Depth (STD) sensor was originally planned for use at the oceanographic stations. This system failed to operate properly. Expendable bathythermographs (XBTs) and a rosette multisampler with niskin bottles were used at each of the 9 selected stations. The XBTs were used to determine the depth for tripping the niskin bottles. Pairs of standard reversing thermometers were read to 0.01°C. Salinity determinations were made to 0.001°/oo using a Guildline "Autosal" Model 8400 laboratory salinometer. The XBT profile values were compared with the reversing thermometer values. In most cases a reasonably consistent error was determined for each XBT profile. Corrections were then applied to the XBT readings for selected depths to the

bottom. Table 1 presents the Station 3 XBT data, reversing thermometer values (rounded to the nearest 0.1°C), temperature difference ($T_{XBT} - T_{THERM}$) at the comparison points, and the corrected XBT values.

Table 1. Corrections for Station 3 XBT Profile

DEPTH (meters)	XBT VALUES (°C)	Reversing Thermometer Values (°C)	Δ T (XBT - Therm)	Correction Applied to XBT	Corrected Temperature (°C)
0	-1.2	-1.1	-0.1	0.1	-1.1
5	-1.2			0	-1.2
10	-1.2			-0.1	-1.1
15	-1.1			-0.2	-1.3
20	-1.1			-0.3	-1.4
25	-1.2			-0.4	-1.6
30	-1.1	-1.6	0.5	-0.5	-1.6
40	-1.0			-0.5	-1.5
50	-1.0	-1.5	0.5	-0.5	-1.5
75	-1.0			-0.5	-1.5
100	-0.6	-1.0	0.4	-0.4	-1.0
125	-0.6			-0.4	-1.0
150	-0.6			-0.4	-1.0
175	-0.5			-0.5	-1.0
200	-0.4	-0.9	0.5	-0.5	-0.9
225	-0.3			-0.5	-0.8
250	-0.2			-0.5	-0.7
300	0			-0.5	-0.5
350	0			-0.5	-0.5
400	0.1	-0.4	0.5	-0.5	-0.4

A multi-year ice floe was selected in the moving pack ice for the high frequency acoustic measurements. A hydrophone was lowered to a depth of 200 meters through a natural melt hole (Figure 2). Ambient noise received by the hydrophone was then filtered into four frequency bands of 5 to 10 kHz, 10 to 20 kHz, 20 to 30 kHz and 40 to 100 kHz and recorded on a 4-channel Sanborn strip chart recorder.

A system developed and built by the Naval Surface Weapons Center and designated the Multiple Influence Sensor System (MISS) was utilized to sense the variations of the following types of ambient parameters: acoustic (2 to 1250 Hz), magnetic (0.01 to 1 Hz horizontal), seismic (10 to 1250 Hz in 3 orthogonal directions), pressure (0.01 to 0.3 Hz), and temperature (-1.8° to 32°C). Since this system must rest on the bottom for seismic measurements, it was necessary that the ice not be moving since dragging along the bottom could cause damage and even loss of the sensor. Therefore, fast ice attached to the Greenland coast was selected for the study area. A 0.6 meter diameter hole was made through the 1 meter thick fast ice, and the sensor was lowered to the bottom (Figure 3). Water depth was about 50 meters. The resultant data were recorded in analog form on both magnetic tape and strip chart.

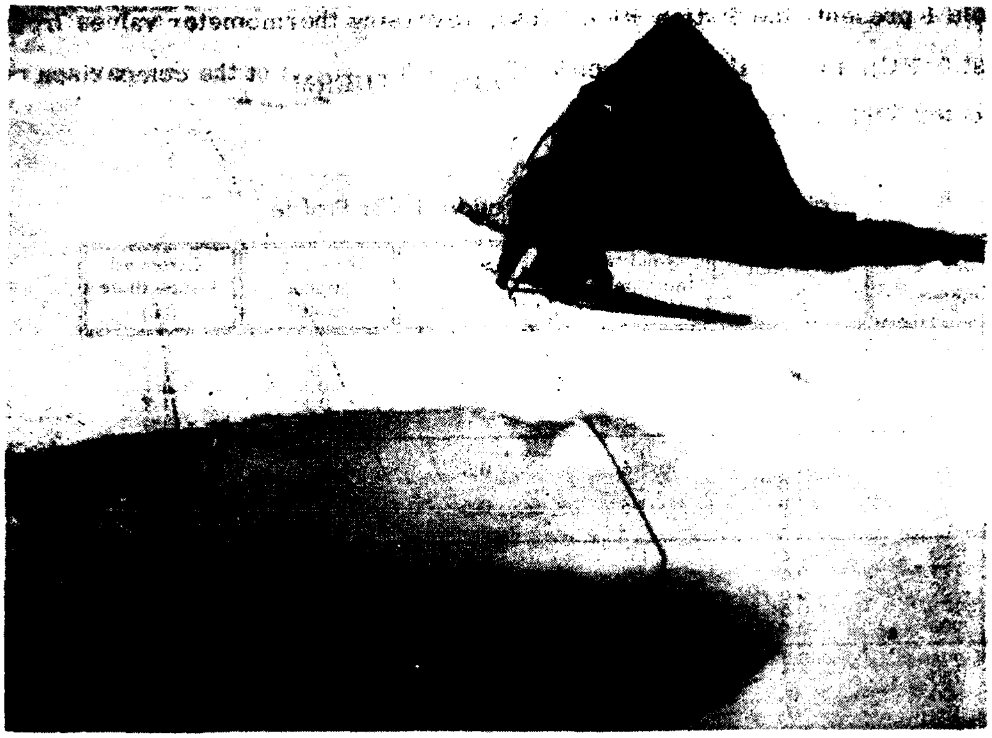

Figure 2. Multi-year ice floe camp

Figure 3. Fast ice camp approximately 2.5 km from Greenland

F. DATA LOCATION AND REPORT STATUS

Bottom sediment samples and photographic data are in the custody of the Naval Oceanographic Office, Washington, D. C., and analysis of these samples should be undertaken in the near future. Analyses of the high frequency and MISS data are being conducted at the Naval Surface Weapons Center, White Oak, Maryland. Results from these analyses will be reported under separate cover.

The remainder of this report will present the bathymetric and magnetic results of this program and discuss in detail the oceanographic features of the northern Smith Sound area.

II. BACKGROUND OCEANOGRAPHY OF SMITH SOUND

The Smith Sound area has long been of interest to Arctic oceanographers, mainly because of the presence of the most well known recurring polynya, the so-called North Water Polynya. This ice-free feature was first observed as far back as 1616 by the British pilot and navigator, Baffin. More recently, the many imaging satellite systems have allowed a more leisurely method of observing this phenomenon and have demonstrated the large yearly variations of its boundaries and yet its remarkable permanence. Figure 4 presents a LANDSAT image of the North Water Polynya/Smith Sound area for 18 July 1977.

Many recent investigations have been conducted in an attempt to determine the mechanisms responsible for the creation and maintenance of this feature; Dunbar (1954), Bailey (1956 and 1957), and Collin and Dunbar (1964), just to name a few. However, the most dedicated program designed to study this feature was the international, interdisciplinary research program entitled Baffin Bay-North Water Project sponsored by the Arctic Institute of North America. Several field programs were conducted under this program and several reports were produced; the major one of which was entitled "The Physical Oceanography of the Northern Baffin Bay Region" (Muench, 1971). In this report, Muench produced a thorough scientific and historical background of the northern Baffin Bay Region. However, despite all available data collected in the north Baffin Bay area, there is still a lack of the northern or narrowest part of Smith Sound between Pim Island and

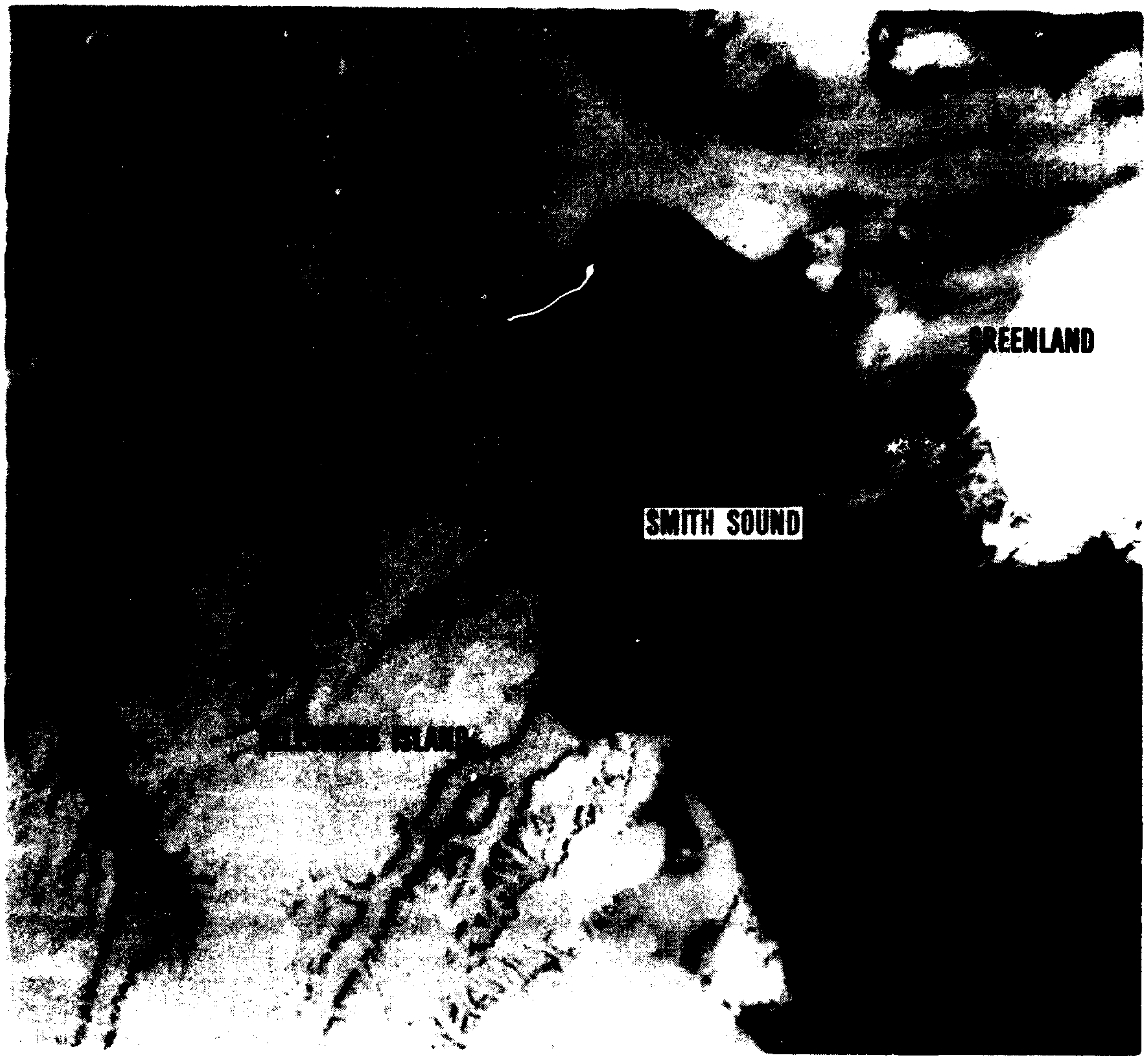

Figure 4. 18 July 1977 LANDSAT image of Smith Sound and North Water Polynya

Greenland. This area is the region of the northernmost part of the North Water Polynya and is just south of the ice dam, a very stable and geographically consistent feature during a majority of the year.

In attempting to determine the mechanisms responsible for the North Water Polynya, studies of the water exchange through Smith Sound have been made by Collin (1965), Muench (1966), and Nutt (1966) among others. These studies, however, were based on dynamic methods, water mass analyses, and studies of glacial ice movements rather than on direct water current measurements. Avis and Coachman (1971) reported results from two current meter stations in southern Smith Sound or northern Baffin Bay. They concluded that the harmonic currents observed were of semidiurnal nature. By filtering to remove semi-diurnal and diurnal harmonics and other high frequency components, the long term components fluctuated with periods of 3 to 4 days. The only other direct current measurement program to date in Smith Sound was reported by Palfrey and Day (1968). However, because of the extremely short lead time available in preparing for their program, instrumentation failures reduced the data yield considerably. Based on the limited data collected, semi-diurnal, tidal circulation was observed which produced a small net transport to the south into Baffin Bay. The conclusion that overall flow is from Kane Basin to Baffin Bay is in almost unanimous agreement with the other investigations cited above. However, Muench (1971) states that northward pulses into Kane Basin may be common.

Water mass analyses (Muench, 1971) have shown that Smith Sound is almost entirely made up of waters originating in the Arctic; i.e., a cold upper Arctic Water layer and a cold Deep Water layer, both defined by temperatures colder than 0°C. Atlantic Water, water warmer than 0°C, has never been observed in Smith Sound (Muench, 1971). However, during the warm summer months, atmospheric warming of the surface waters does occur.

The remainder of this paper will discuss the oceanographic conditions observed during July 1977 from USCGC WESTWIND and will attempt to show that a major influx of warm, dense water (possibly Atlantic Water) does occur from the south along the eastern portion of northern Smith Sound, and that a cold Arctic mass flows south on the western side of the sound. It does appear that the northern Smith Sound area is oceanographically very complex due to the meeting of these water masses.

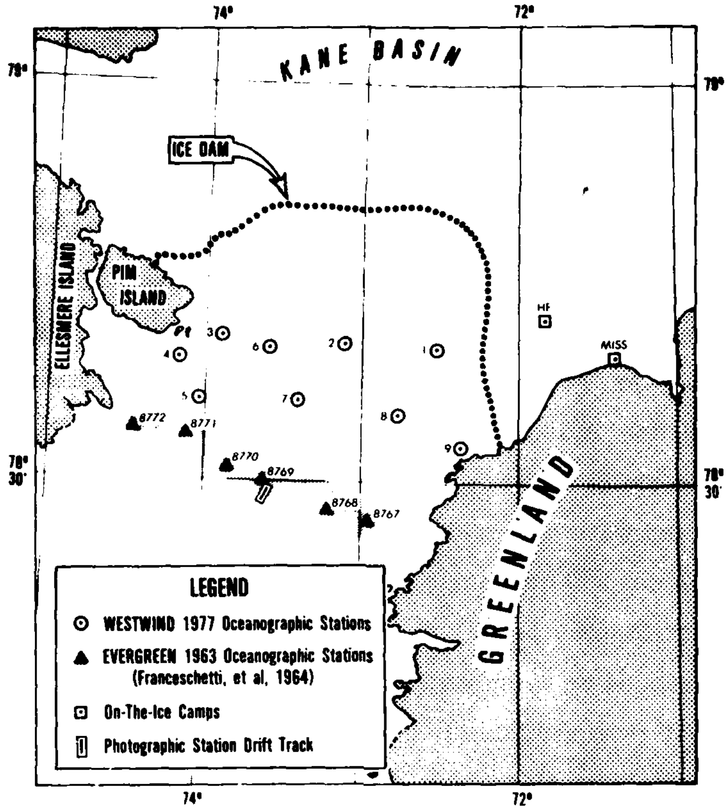

Figure 5. Station locations for 1977 WESTWIND cruise. *EVERGREEN 1963* stations in Smith Sound are also plotted.

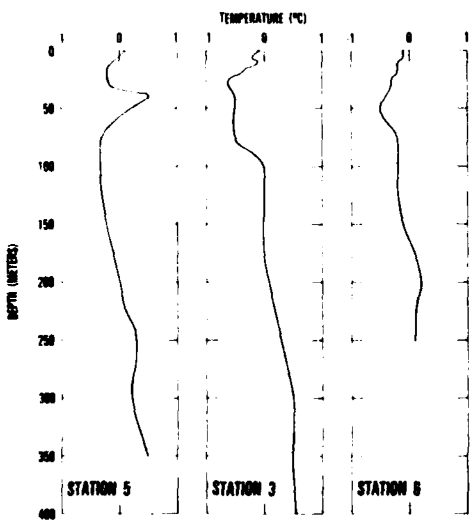

Figure 6. Vertical temperature structure at stations 5, 3, and 6.

III. WATER MASS CHARACTERISTICS IN NORTHERN SMITH SOUND

Figure 5 presents the locations of the 9 oceanographic stations occupied during the 1977 WESTWIND mission.

Figure 6 presents the vertical temperature structure observed at stations 3, 5 and 6. The features of interest demonstrated by these profiles are a positive temperature gradient at Station 5 centered at 40 meters and isothermal areas at Stations 3 and 6 at about 50 and 75 meters, respectively. A similar feature was observed in 1963 by Franceschetti et al (1964) at 50 to 75 meters depth. The vertical temperature profiles for their stations 8770 and 8771 are presented in Figure 7, and the locations of these stations are plotted in Figure 5. To best show what may actually be happening here, vertical cross sections were constructed along the near West-East line of stations in Figure 5. Figure 8 presents the more southerly of the two sections. Between Stations 7 and 8 there is a mass of warmer water which is limited to the upper 100 meters at Station 7 and extends to the bottom at Station 8. On the western side of the sound, a cold mass exists with the coldest part (core) of this mass around 100 to 125 meters. At this latitude, the cold mass is well-defined by the -1.0°C isotherm with its core defined by the -1.2°C isotherm. The influences of the warmer water to the east can be seen at Station 5 with the warm intrusion, extending into the colder water at 40 to 50 meters depth, creating the rise in temperature shown in Figure 6.

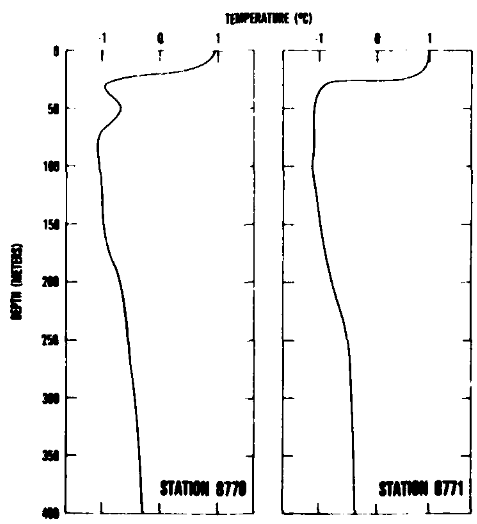

Figure 7. Vertical temperature structure at 1963 EVERGREEN stations 8770 and 8771 (from Franceschetti et al, 1964)

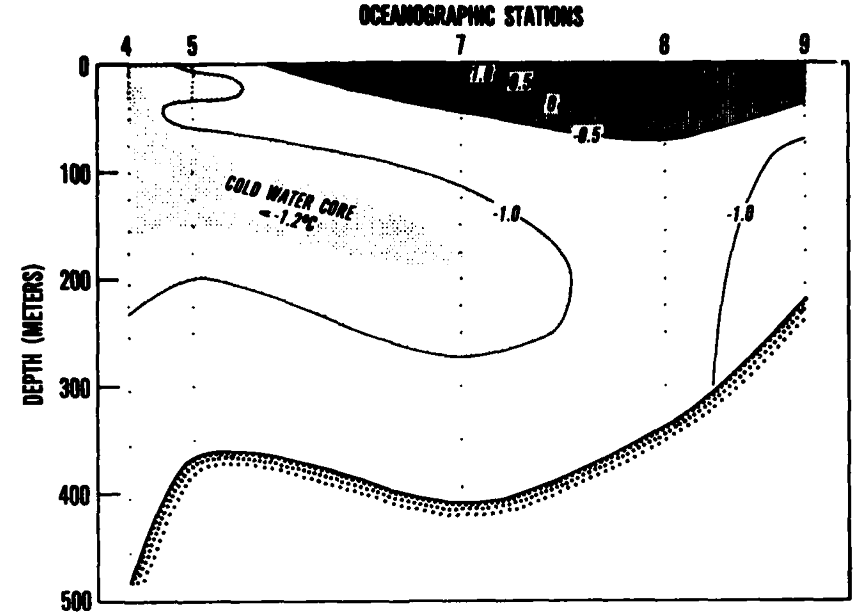

Figure 8. Temperature distributions along southernmost line of stations

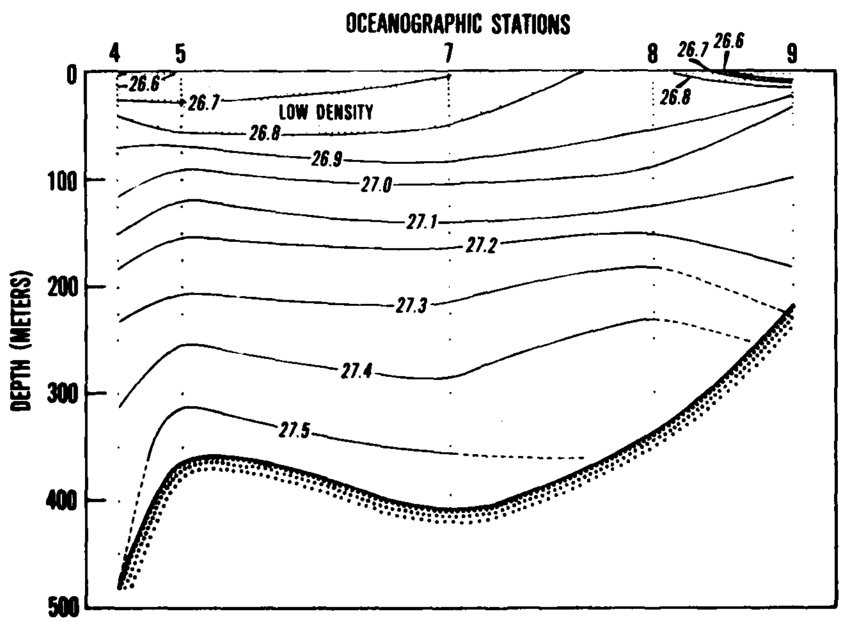

Figure 9. Density (σ_t) distributions along southernmost line of stations

Although the warmest temperatures are observed at Station 7, it is likely that the high temperatures at the surface are due to atmospheric heating and that the warm water mass is entering northern Smith Sound closer to Station 8. Figure 9 presents the density (σ_t) distributions along the same line of stations. The bending of the 26.8 isopycnal toward the surface between Stations 7 and 8 and the general higher density water at Stations 8 and 9 between 20 and 150 meters indicates that there is an influx into this area of warmer, denser water than that observed to the west. A plan view of the density variations of the study area at a depth of 30 meters is presented in Figure 10. This figure also delineates the influx of denser water into the study area between Stations 7 and 8 and also the influx of less dense water on the western side of the sound from the north.

The effects of low salinity runoff from the land masses are readily apparent in Figure 9 by the two values observed at the surface at both Stations 4 and 9.

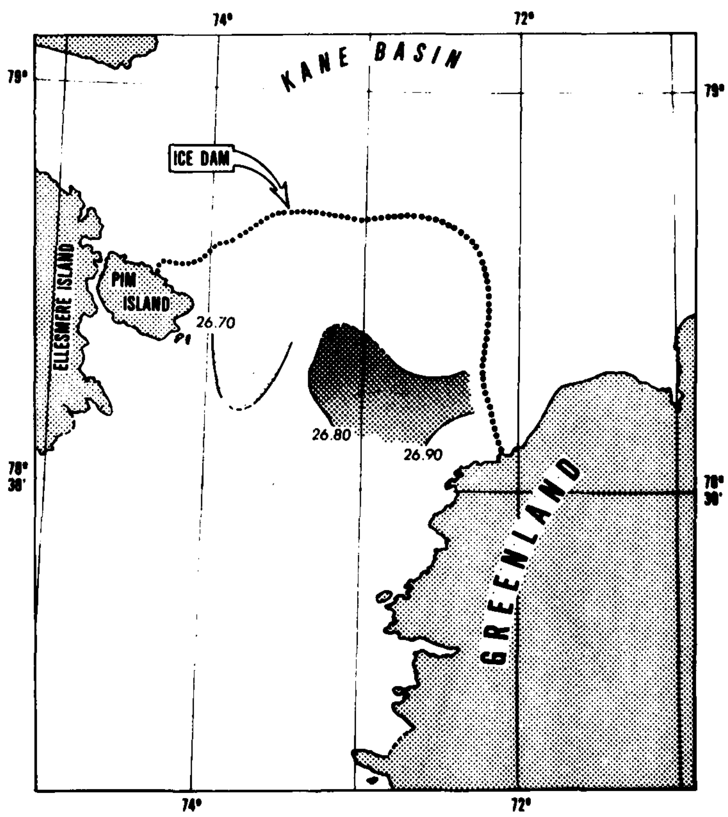

Figure 10. Density (σ_t) variations in Northern Smith Sound at a depth of 30 meters

A study of the northern line of stations allows a determination of the directions of flow of the cold and warm masses. Figure 11 presents the temperature distributions along this line. The two lines of stations are separated by only about 12 kilometers, yet severe modifications to the warm mass have already taken place. To the south the warmer mass was ill-defined by the -0.5°C isotherm and was spread out over a good portion of the sound. Now to the north, the warm mass is well-defined by the -1.0°C isotherm and reasonably compact. The cold water core is better defined by the -1.5°C isotherm rather than the -1.2°C isotherm used in Figure 8. The effect of the warm water on the vertical temperature structure at Stations 3 and 6 is still apparent by the graphic intrusion into the cold mass depicted by the -1.0°C isotherm. Another effect is the forcing of the colder, less dense water to greater depths. To the north, the cold mass is continuous from 10 meters to about 100 meters (with the exception of the intrusion at about 75 meters at Station 6). To the south, the downward slope of the -1.0°C isotherm shows that this water mass is being forced to greater depths. In fact, the deeper -1.0°C isotherm, which usually can represent the boundary between the coldest water in the column, and the gradual rise in temperature to the bottom due to adiabatic heating, has been destroyed at Station 8 by the warm water entering northern Smith Sound from the south.

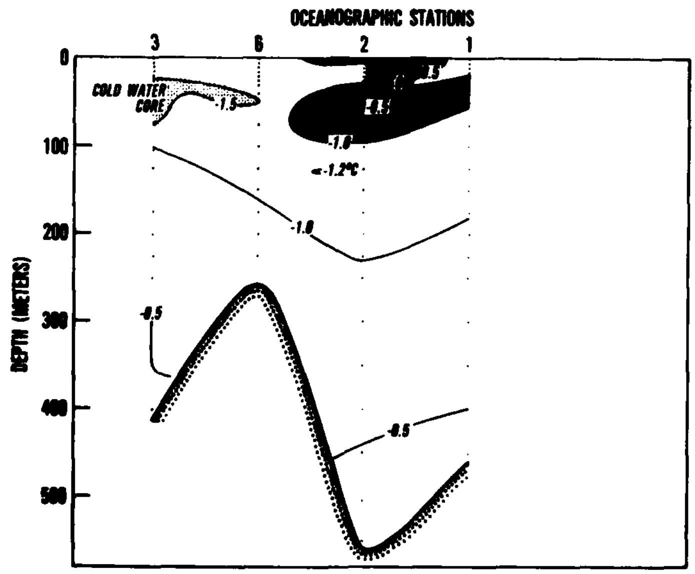

Figure 11. Temperature distributions along northernmost line of stations

Franceschetti et al (1964) presented a temperature cross section located approximately 20 kilometers south of the southernmost WESTWIND line shown in Figure 8. The stations utilized for their cross section were occupied approximately 2 weeks later into the summer season, and the surface values are higher. However, below the upper 30 meters, the same warm mass can be observed. Figure 12 is a replot of their data. The dotted line between Stations 8771 and 8770 indicates the original plot of their upper -1.0°C isotherm, and the solid line in this area represents the likely structure based on the 1977 WESTWIND results. In other words, Figure 12 considers the -1.00°C value, observed at about 30 meters depth at Station 8770, which was reasonably ignored during the original analysis. Again, as in Figure 8, warm water (>-1.0°C) is intruding into the -1.0°C isotherm at Station 8770 creating a situation very similar to that depicted in Figure 8.

Based on the analysis of the cross sections presented here, it does appear that a warm, higher density water is entering Kane Basin through the eastern portion of Smith Sound. Once in Kane Basin, this water mass is quickly modified by the cold water to the north and west and loses its identity to the west. On the western side of the sound, a cold mass is egressing from Kane Basin toward Baffin Bay. Near center channel, a complex interaction between these different masses is taking place. Generally the warm water is intruding into the colder water at a depth of about 50 to 75 meters.

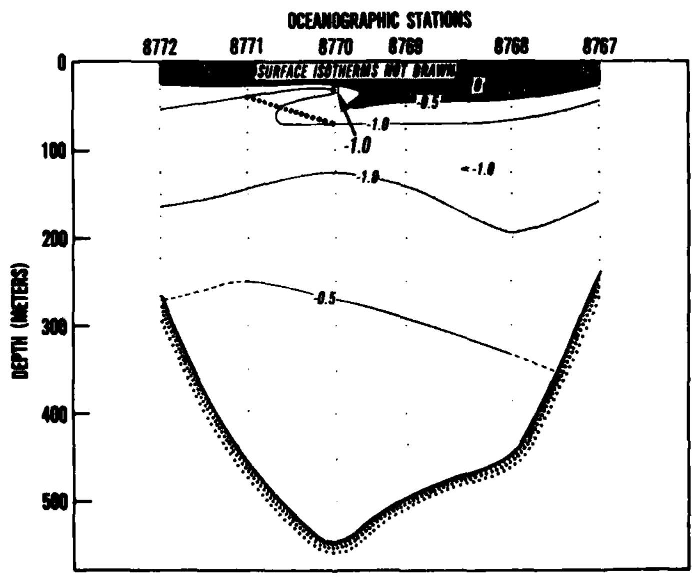

Figure 12. Replot of Franceschetti et al (1964) temperature distributions along a line of stations in Smith Sound

It is generally agreed that net flow is from Kane Basin through Smith Sound into Baffin Bay. However, it is also felt that pulses into Kane Basin from the south are common (Muench, 1971). The structure as shown here could be one of these pulses and may be short-lived. However, the similarity to the situation observed in 1963 by Franceschetti et al (1964) indicates that these flow patterns may be more permanent than originally believed. It is more likely that the flow patterns described herein may be seasonal in nature, i.e., spring or early summer features. If the latter case is true and the northerly flow is a seasonal or semipermanent phenomenon, it is possible that the participant warmer, dense water could have originated in the Atlantic. At the latitude of northern Smith Sound, such extreme modification could have taken place as to make this water unrecognizeable as Atlantic Water, when utilizing the normal temperature-salinity definitions for identification.

IV. OTHER OCEANOGRAPHIC FEATURES OF NORTHERN SMITH SOUND

A. BATHYMETRY

Figure 13 presents a summary of the bathymetric data collected on this mission. In compiling the data used to produce Figure 13, five West-East lines were run with a spacing of about 4.6 kilometers (Figure 1). Four additional North-South lines were run with variable spacing and were used to check the viability of the West-East lines, especially at the crossing points. Generally, northern Smith Sound appears to have a very irregular bottom with many fairly steep-sided undulations. Maximum depths were about 608 meters (333 fathoms) and generally were found east of center channel. The contours presented in Figure 13 provide only a general description of the bathymetry of northern Smith Sound. A comparison of the 1977 WESTWIND data with available and most recent charts showed wide disagreements throughout the survey area. For cartographic purposes, however, a finer-grained survey, such as 1 kilometer line spacing, with state-of-the-art geographic positioning should be conducted. Until that time, the contours presented in Figure 13 probably represent the most reliable information available.

B. MAGNETIC ANOMALY DATA

Figure 14 presents a magnetic anomaly profile along the eastern side of Smith Sound. Although the entire 5-line grid was not completed, precluding the preparation of an anomaly

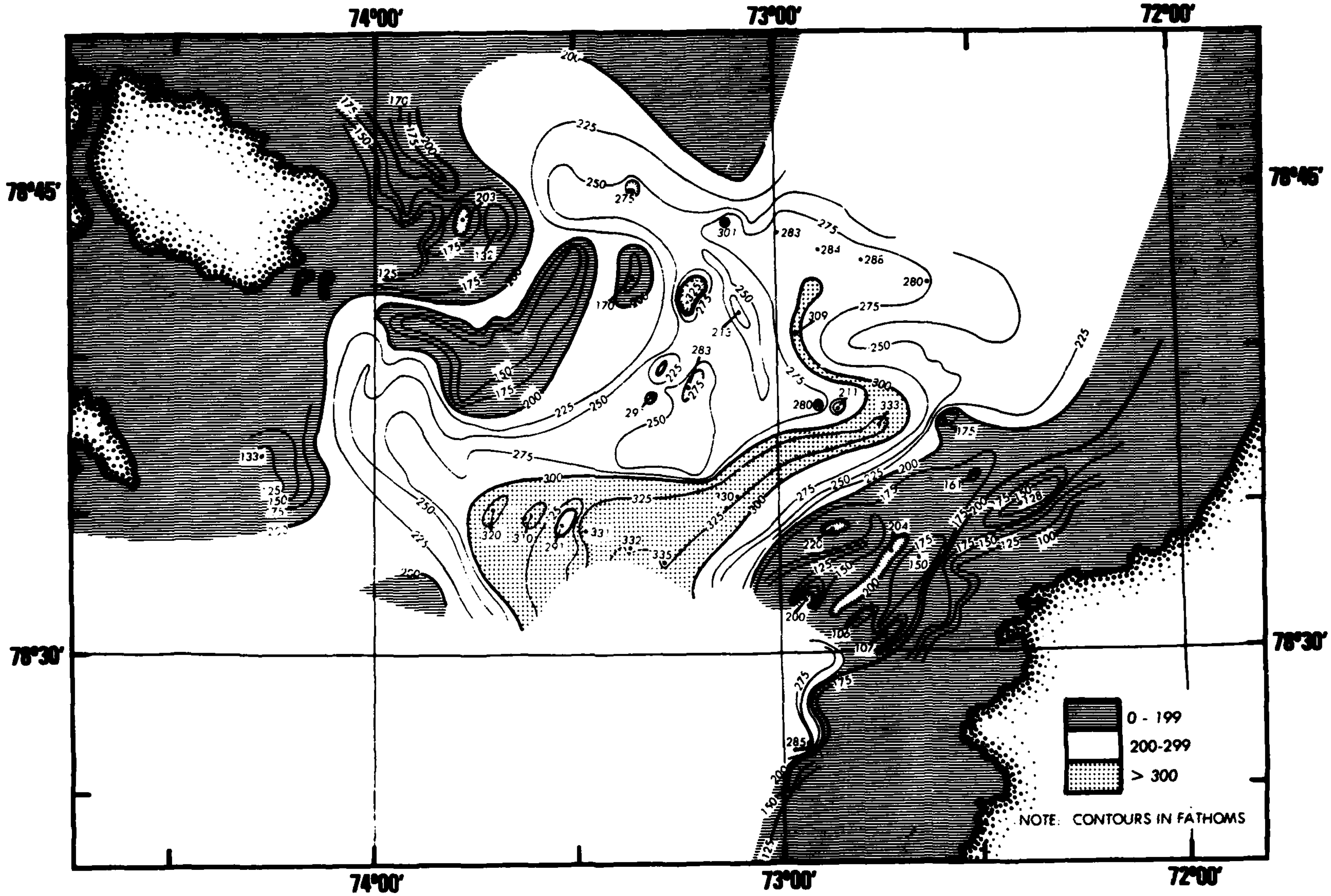

Figure 13. Bathymetric contours within Northern Smith Sound

contour chart, enough data were collected to suggest that the magnetic anomalies are oriented northeast-southwest, or along the axis of Smith Sound, and that the stronger anomalies lie to the south. The extreme northern portion of Smith Sound just south of the ice dam was observed to be magnetically very uniform at about 56,650 gammas.

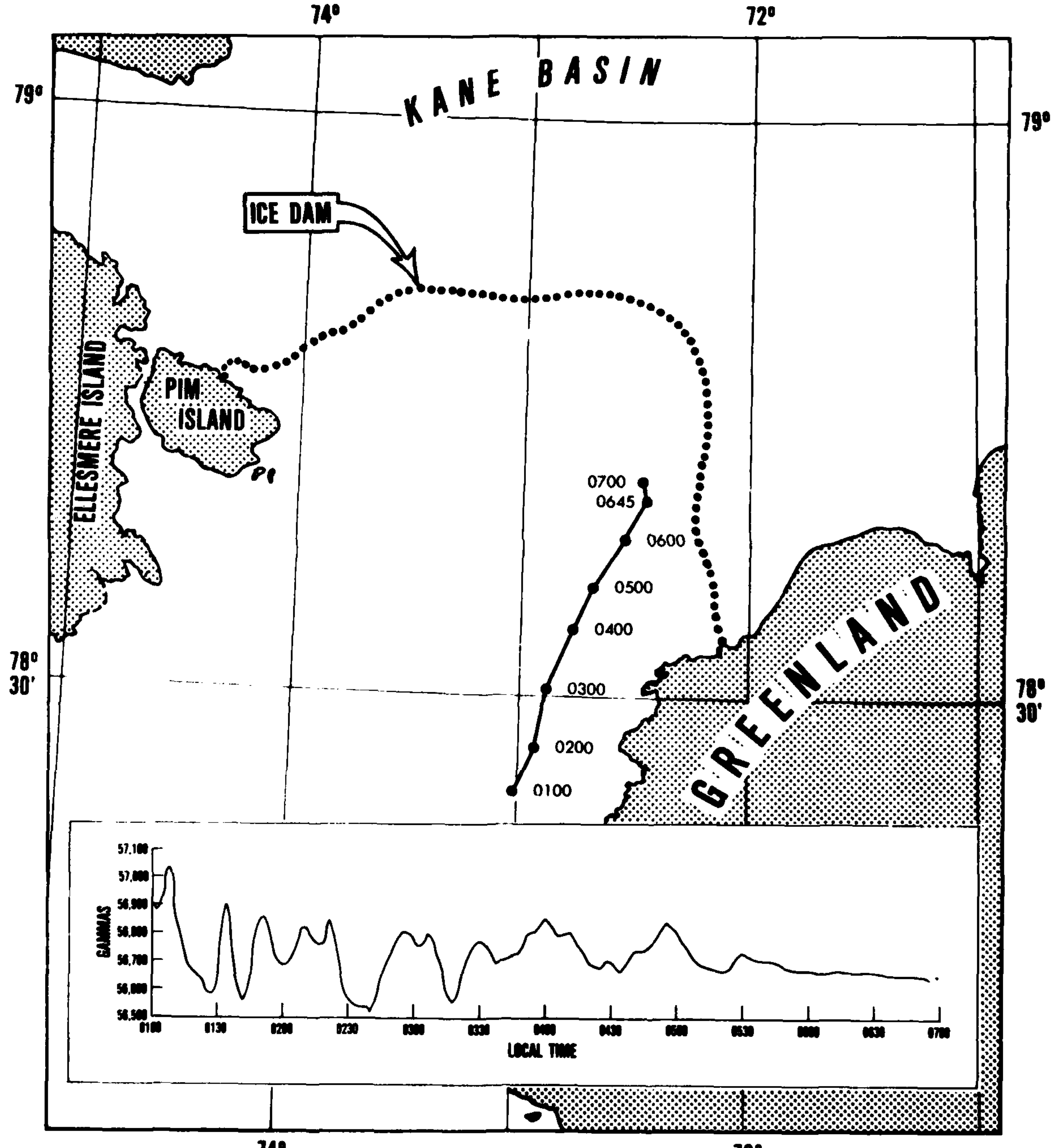

Figure 14. Magnetic anomaly profile along Eastern Smith Sound

C. TEMPERATURE VS SALINITY PLOTS

Figure 15a presents a composite of the temperature-salinity (T-S) relationships of the 9 oceanographic stations occupied by WESTWIND. Figure 15b presents a T-S composite presented by Muench (1971). Although the majority of the Muench data were collected in the central and southern portions of Smith Sound, there is still a reasonable agreement between the two sets of data, especially below 100 meters. A wide variety of values are to be expected in the upper 30 meters due to atmospheric heating/cooling and fresh water runoff. The variations between the depths of 30 and 100 meters must be due primarily to the sampling within both the warmer and colder water masses discussed in Section III above.

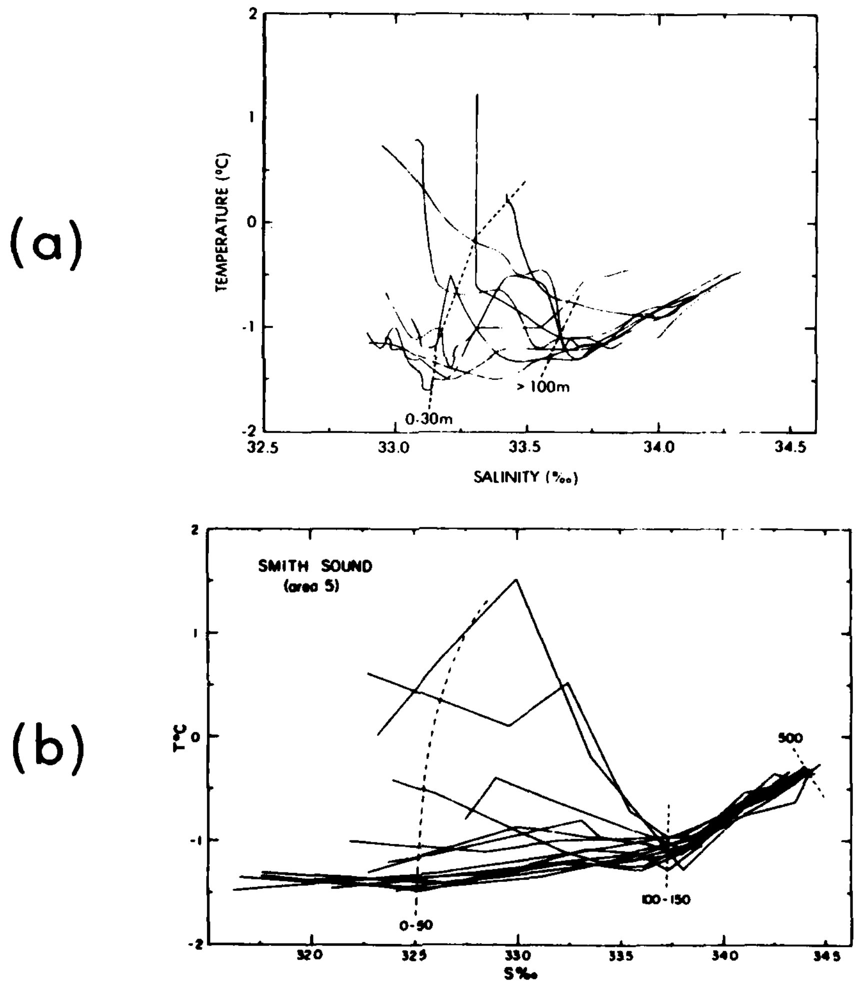

Figure 15. Comparison of T-S relationships between 1977 WESTWIND data (a) and that compiled by Muench (1971) (b)

V. CONCLUSIONS AND RECOMMENDATIONS

During the summer, northern Smith Sound appears to be an oceanographically complex region. This complexity is primarily created by the meeting of significantly different water masses. The eastern side of the sound is dominated by a warm, dense mass from the south, and the west is dominated by a cold, less dense mass from the Arctic. These water masses are surface features. The warmer mass is limited to the upper 100 meters, and the colder mass deepens to the south, extending to about 200 meters. The waters shallower than 30 meters are highly variable due to atmospheric heating/cooling and fresh water runoff from the nearby land masses.

The warm feature in eastern Smith Sound may be a semipermanent seasonal phenomenon rather than a short-lived oscillation created by atmospheric mechanisms such as barotropic forcing. If this conclusion is true, the warm, dense water may be highly modified water originating in the Atlantic.

To more confidently define the characteristics of these interacting water masses in northern Smith Sound, and to determine the mechanisms responsible for their actions, a series of close-grid oceanographic stations should be occupied throughout the spring-summer season. The grid should cover the extreme southern Kane Basin around 78°50'N down to 78°20' in Smith Sound. Most importantly, several bottom-moored current meter arrays must be implanted within the study area defined above. Measurements must be concentrated in the water column between 30 and 200 meters. The measurement period should encompass the entire spring-summer seasons. If possible, the arrays should be replanted for measurements through the fall and winter seasons. For these fall-winter measurements, meters in the upper 60 meters may not be feasible because of the danger of deep-drafted transient icebergs through Smith Sound from the north.

The northern Smith Sound region is also complex in its bathymetry and magnetic anomaly characteristics. Water depths in this area are extremely variable, and the magnetic anomaly variations are completely dissimilar within a separation of only 20 kilometers. Because of this extreme variability, a close-knit grid with 1 kilometer line spacing is

required to adequately describe the bathymetric and magnetic anomaly characteristics. Subbottom reflection data are also highly desirable. Geodetically correct points have been determined on nearby land masses. With some effort using helicopters, a portable navigation system can be deployed using these known points to insure precise positioning of the grid lines.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Naval Ocean Research and Development Activity conducted an oceanographic research program in Northern Smith Sound during middle July 1977 using USCGC WESTWIND (W-AGB 281) as the data collection platform. One aspect of the program was to investigate the water mass interactions at the narrowest portion of Smith Sound which: (1) represents the boundary between this sound and Kane Basin to the north; and (2) is the area of the most well-known semipermanent open water area--the North Water Polynya.

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20. ABSTRACT (Continued)

From an analysis of 2 West-East cross sections and a comparison of these data with data collected by the Coast Guard in 1963, it is suggested that the Northern Smith Sound area is a meeting area of two different water masses: (1) a warm (>-1.0°C), dense (>26.8 σ_t) mass on the eastern side of Smith Sound which enters the area from the south; and (2) a cold (<-1.0°C), low density (<26.7 σ_t) mass on the western side of Smith Sound which originates in the Arctic.

It is further suggested that since the warm, dense water mass was also observed in 1963, this feature in eastern Smith Sound may be a permanent or, more likely, a semipermanent (seasonal) phenomenon and could be highly modified Atlantic Water. This latter conclusion is in contrast to the general belief that Atlantic Water does not enter Smith Sound.